# Bank Holding Company Interest Rate Risk and its Drivers

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## Abstract

This study expands the current literature on the sensitivity of bank holding company (BHC) stock returns to changes in interest rates and the BHC-specific factors that affect these sensitivities. Consistent with previous research, in general I find a negative relationship between stock returns and interest rate movements for the unanticipated interest rate changes associated with both the 3-month and 10-year Treasuries. I also identify three bank-specific factors found on and off the balance sheet that help explain these sensitivities.

This paper utilizes Vector Autoregression analysis to form two series of unanticipated interest rate changes. Also, an expanded sample period is studied through 2006, which consequently allows for the use of more detailed interest rate derivative information in estimating the impact of derivatives usage on BHC interest rate sensitivities. Lastly, testing is performed on three distinct sub-periods, in addition to an overall sample period, in order to analyze parameter stability over time.

## 1. Introduction

The sensitivity of commercial banks to the interest rate environment is an important factor that has significant effects on bank performance and economic activity. The negative consequences of mismatched rate sensitive assets and liabilities became especially clear in the 1980's when rising rates contributed heavily to the collapse of many savings and loans in the US.

Fraser, et al (2002) argues that in more recent years, much of the analysis has focused on two interrelated questions: Are bank stock returns sensitive to interest rate changes and are these sensitivities associated with particular asset and liability characteristics of the individual banks?

This paper contributes to the existing literature by first utilizing Vector Autoregression analysis to form two series of unanticipated rate changes, as opposed to simple changes in rates, in the estimation of Bank Holding Company interest rate sensitivity. Some of the existing literature has included predicted rates to control for the market's anticipation of rate changes. None have utilized VAR analysis, however, which accounts for the cointegration found among the various Treasury rate series by Bradley and Lumpkin (1992) and others.

This paper also expands the sample period through 2006, allowing for a more detailed examination of the effects of interest rate derivative usage on interest rate risks associated with the BHC's sampled. Of the relatively few studies utilizing interest rate derivatives, to my knowledge, none have considered strictly non-traded interest rate derivatives, due in part to the fact that derivatives information provided in quarterly Y-9C reports did not differentiate between non-traded and traded derivatives prior to 1995. The assumption is that interest rate derivatives classified as "non-traded" are utilized to reduce interest rate sensitivity through hedging transactions.

Lastly, in order to analyze the stability of the estimated parameters, testing is performed on three 4-year sub-periods in addition to the overall 12-year sample period. Most of the literature, in contrast, has addressed only one sample period. Hirtle (1997) is one exception – in her study, two sub-samples are addressed.

I find that overall, BHC stock returns are negatively impacted by unanticipated interest rate increases, consistent with much of the existing literature. I also identify three bank-specific factors that are found to impact, to various degrees, the variation in BHC interest rate sensitivities – two of the factors utilized are on-balance sheet measures and one is an off-balance sheet measure.

## 2. Existing Literature

Existing literature has considered the issue of Bank Holding Company interest rate risk in some detail. Much of this research specifically addresses the impact of interest rate changes on stock returns – with some of the research delving further into the analysis through different techniques.

Ghazanfari, Rogers and Sarmas (2007) utilize an event study methodology which focuses on two event dates reflecting shifts in Federal Reserve policy to determine BHC stock reactions to these events. The authors then utilize four strictly on-balance sheet measures (relative levels of equity, interest income, demand deposits, and liquid securities) to estimate varying sensitivities to the events. The ratios of equity-to-total assets and securities portfolios-to-total assets were found to be statistically significant in their study.

Fraser, Madura and Weigand (2002) also study the impact of interest rates on BHC stock returns. They utilize an ARIMA methodology to create a series of predicted short- and long-term rates. Unanticipated rate changes are then formed to estimate the sensitivities of BHC stock returns to these unanticipated changes. Consistent with the majority of the related literature, a negative relationship is found between unanticipated changes in interest rates and returns. Like Ghazanfari, et al, only on-balance sheet measures (relative levels of equity, non-interest income, total loans, and demand deposits) are utilized to explain varying interest rate sensitivities.

Hirtle (1997) also considers the effect of interest rates on BHC stock returns, by utilizing yield levels of the 10-year T-Note – the effects of varying short-term rates are not considered. In the second stage of Hirtle's analysis, a number of on-balance sheet items are considered along with total notional amounts of interest rate derivatives. Derivatives information taken from Y-9C's over the sample period in this study (1986 to 1994) is less detailed than the information provided in the reports beginning in 1995. No distinction was previously made in the Y-9C's between derivatives held for trading and those not held for trading. This could potentially affect the results since derivatives held for trading do not serve as hedging tools. Ultimately, the results specifically related to interest rate derivative usage in this paper indicate that during the 1991-1994 period, interest rate derivative usage was positively related to interest rate sensitivity, which could be indicative of speculation on future interest rate moves. The economic significance of this relationship, however, appears to be small, especially when compared to the relative impact of the of the various on-balance sheet explanatory variables.

Overall, the majority of the literature finds a negative relationship between BHC stock returns and interest rate movements. However, the bank-specific factors determined to impact individual bank stock sensitivities vary among studies, with most utilizing a variety of strictly on-balance sheet measures as explanatory variables.

## 3. Data and Empirical Methodologies / Results

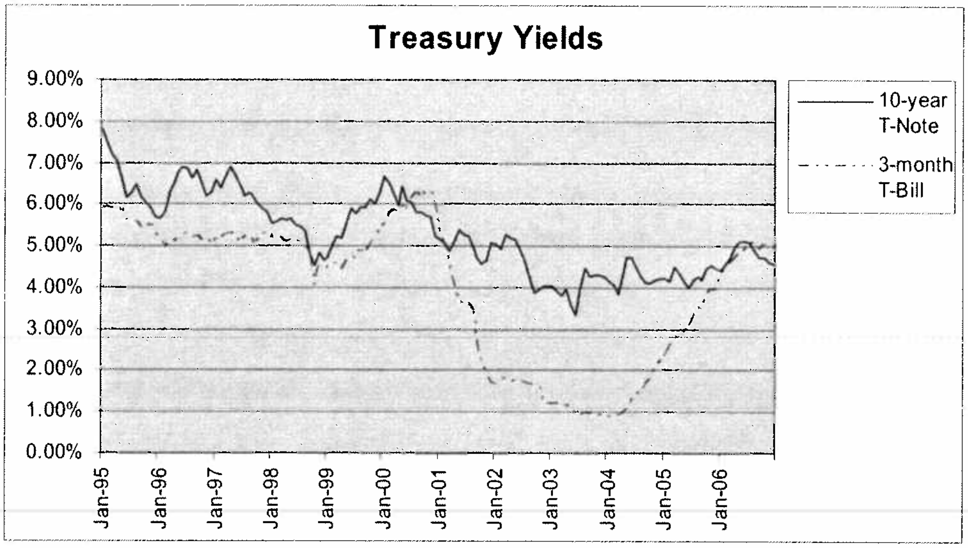
Empirical testing is done in three stages. Stage 1 focuses on the analysis of various Treasury yield series with the ultimate outcome being a predicted series for both the 3-month T-Bill and the 10-year T-Note. From these predicted rates, I form unanticipated rate changes for both yield series by subtracting the predicted rates from the corresponding realized rates. This step controls for market-anticipated changes in interest rates (as modeled), leaving only unanticipated changes in the estimation of individual BHC stock sensitivities.

In Stage 2, I utilize the unanticipated rate changes from Stage 1 along with equal-weighted market returns from CRSP as explanatory variables with individual BHC returns as the dependent variable. This testing is performed separately for both series of unanticipated rate changes.

Stage 3 utilizes various on- and off-balance sheet items in order to identify and estimate the drivers of the sensitivities determined in Stage 2.

Testing performed in Stages 2 and 3 addresses three 4-year sub-periods in addition to the overall 12-year sample period, spanning from 1/95 to 12/06. The VAR analysis performed in Stage 1 is based on an "estimation" period spanning from 1/70 through 12/94. The results derived from the estimation period are then applied to the overall 12-year "prediction" period (or overall sample period).

Sub-Period 1, which ranges from 1995 through 1998, is generally characterized by stable short-term rates and by slightly more volatile long-term rates. Sub-Period 2 (1999 through 2002) is represented by a similar pattern in long-term rates while short-term rates are falling through most of the sub-period, especially in 2001. Sub-Period 3 (2003 through 2006) reflects lower variability and lower levels associated with long-term rates while short-term rates increase during much of the sub-period.




During the overall sample period, BHC's experienced considerable growth with average asset size increasing from $3.6 billion at the end of 1995 to $12.6 billion at the end of 2006. On the other hand, the total number of BHC's fell slightly from 6,109 to 5,709 during the same period.[1]

In order to limit BHC's being studied to those with appreciable trading volume and liquidity, the sample includes only publicly traded BHC's with total assets in excess of $2.5 billion as of the end of 2006. These stocks presumably react more readily to new information than many of the smaller omitted BHC's. The sampled BHC's are not required to be in existence (as defined by having a unique CUSIP) throughout the entire sample period and there is no required minimum number of observations for each.

Table 1 provides basic information on asset size and the number of sampled BHC's. As evidenced by considerably lower median asset size in relation to mean asset size, total assets within the sample are dominated by relatively few large institutions. In all of the subsequent analysis each BHC is weighted equally.

**Table 1 – Bank Holding Company Asset Size**

| Sub-Period | Mean* | Median* | N |
|---|---|---|---|
| 1995 - 1998 | $31,519,890 | $4,084,314 | 122 |
| 1999 - 2002 | $47,050,463 | $6,126,290 | 128 |
| 2003 - 2006 | $81,023,582 | $8,707,515 | 130 |

**in thousands*

[1] Taken from the Federal Reserve Bank of Chicago's Bank Holding Company Data (http://www.chicagofed.org/economic_research_and_data/bhc_data.cfm)

**Stage 1**

The historical US Treasury yields utilized in this stage are obtained from the Federal Reserve Statistical Release H.15. I use monthly 3-month, 3-year, and 10-year constant maturity yields to form a prediction model for both the 3-month and 10-year rate series.

The majority of the existing literature on Treasury yields has found the various series to be non-stationary, unit root processes. Engle and Granger (1987) and Bradley and Lumpkin (1992) are two examples. Table 2 provides the results of unit root testing of the T-Bill and T-Note time series over the entire prediction period of 1/95 to 12/06. Similar results were found for the entire estimation period of 1/70 to 12/94.

**Table 2 – Augmented Dickey-Fuller Tests for Unit Root Processes**

| | 3-Month T-Bill Yield | | | 10-Year T-Note Yield | | |
|---|---|---|---|---|---|---|
| | Test Stat | CV - 5% | Reject? | Test Stat | CV - 5% | Reject? |
| $\Delta y_t = \gamma y_{t-1} + \varepsilon_t$ *(no constant)* | -1.345 | -1.950 | No | -1.451 | -1.950 | No |
| $\Delta y_t = a_0 + \gamma y_{t-1} + \varepsilon_t$ *(with constant)* | -2.192 | -2.860 | No | -1.353 | -2.860 | No |
| $\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \varepsilon_t$ *(with constant, with trend)* | -0.775 | -3.410 | No | -2.411 | -3.410 | No |
| $\Delta y_t = a_0 + \gamma y_{t-1} + \sum_{i=2}^{48} \beta_i \Delta y_{t-i+1} + \varepsilon_t$ *(with constant, with lags, no trend)* | -2.447 | -2.860 | No | -2.147 | -2.860 | No |
| $\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \sum_{i=2}^{48} \beta_i \Delta y_{t-i+1} + \varepsilon_t$ *(with constant, with lags, with trend)* | -2.164 | -3.410 | No | -2.124 | -3.410 | No |

The null hypothesis of a unit root process is not rejected in any of the Augmented Dickey-Fuller variations as indicated. Three possible methods of converting unit root processes for econometric testing include: first-differencing the series, de-trending the series, or modeling predicted values utilizing VAR estimation.

VAR analysis using yield levels of various maturities on the treasury yield curve is considered by some to be superior to first-differencing if cointegration is indicated within the system. According to Bradley and Lumpkin (1992), "information about potential (long run) relationships between the levels of economic variables is lost" when time series are first differenced. In their paper, the authors test seven different treasury series for cointegration: 3-Month, 1-Year, 3-Year, 5-Year, 7-Year, 10-Year, and 30-Year. Bradley and Lumpkin utilize the Granger and Engle two-step procedure to test for cointegration. First, each yield series is regressed on a constant and the other six rates. The residuals are then tested for auto-correlation and for stationarity. Their results reject "non-cointegration" for all of the equations' residuals with statistically significant Durbin-Watson statistics and Dickey-Fuller statistics. The cointegration hypothesis is reasonable considering the fact that these securities differ primarily in time to maturity – any large variation would likely result in arbitrage-like opportunities otherwise.

The VAR analysis in this paper considers only three of the seven yield series analyzed by Bradley and Lumpkin – the 3-month, 3-year, and 10-year Treasuries. Over the entire estimation period of 1/70 to 12/94 and the entire prediction period of 1/95 to 12/06, the three treasury yield series are found to be cointegrated based on the methodology utilized by Bradley and Lumpkin (1992).

Based on the cointegration and unit root testing results, a VAR model is then run over the estimation period to predict yield levels during the prediction period. A number of lag structures are considered in estimating the model, but ultimately, the VAR model based on one- and two-month lags is chosen based on optimal AIC and SBC values. The results of this estimation are listed in Table 3.

**Table 3 – VAR Estimations (4/70 to 12/94)**

| | 3-Month Treasury | | 10-Year Treasury | |
|---|---|---|---|---|
| | Coef. | P>\|z\| | Coef. | P>\|z\| |
| **3-MonthTreasury** | | | | |
| 1-Month Lag | 1.077 | 0.000 | 0.085 | 0.237 |
| 2-Month Lag | -0.049 | 0.731 | -0.020 | 0.779 |
| **3-Year Treasury** | | | | |
| 1-Month Lag | 0.208 | 0.049 | 0.078 | 0.161 |
| 2-Month Lag | -0.350 | 0.245 | -0.221 | 0.042 |
| **10-Year Treasury** | | | | |
| 1-Month Lag | 0.053 | 0.189 | 1.069 | 0.000 |
| 2-Month Lag | 0.085 | 0.822 | -0.002 | 0.994 |
| **Constant** | -0.002 | 0.663 | 0.001 | 0.404 |
| $R^2$ | 0.9504 | | 0.9564 | |

As shown, the largest coefficient for the 3-month Treasury rate is its own one-month lag. It is also found to be statistically significant at the 1% level. A similar result is found when considering the 10-year T-Note. Based on these rate prediction models, two series of unanticipated interest rate changes are formed by subtracting the predicted rates from the corresponding realized rates.

## Stage 2

Stage 2 of the analysis regresses BHC equity returns on the unanticipated changes in the 3-month and 10-year Treasury yields estimated in Stage 1 and on monthly Equal-Weighted Market Returns from CRSP. Two models are estimated – one for each yield series – in order to consider the impacts of short-term and long-term unanticipated rate changes.

A negative coefficient associated with short-term rates (3-month T-Bill) would be consistent with the hypothesis that unanticipated increases in the T-Bill yield can negatively impact returns by increasing funding costs, such as short-term deposits, while rates on long-term assets, such as fixed-rate loans, do not rise as quickly to offset costs.

A negative coefficient associated with long-term rates (10-year T-Note) would be consistent with the hypothesis that most banks hold higher-duration assets in contrast to lower-duration liabilities. This duration mismatch, closely related to maturity mismatches between assets and liabilities, is fundamentally tied to the intermediation provided by the banking industry.

Table 3 provides pooled estimates of the coefficients describing market reaction to unanticipated changes in the 3-month T-Bill for each sub-period and for the overall estimation period. Table 4 provides the same estimates for the 10-year T-Note.

**Table 3 – Two-Factor Model: Unanticipated Changes in the 3-Month T-Bill**

| | $\alpha$ | $\beta_1$ | $\beta_M$ | $R^2$ | n |
|---|---|---|---|---|---|
| 1995 - 1998 | 0.018 | -2.814 | 0.669 | 0.187 | 12,762 |
| | (28.26)*** | (-7.14)*** | (52.49)*** | | |
| 1999 - 2002 | 0.007 | -2.406 | 0.097 | 0.011 | 13,449 |
| | (9.51)*** | (-7.14)*** | (8.84)*** | | |
| 2003 - 2006 | 0.000 | 0.518 | 0.558 | 0.151 | 13,318 |
| | (0.34) | (1.45) | (48.62)*** | | |
| 1995 - 2006 | 0.012 | -2.346 | 0.325 | 0.061 | 39,531 |
| | (31.24)*** | (-12.26)*** | (47.94)*** | | |

**For all BHC's ('b'):**

$$R_{bt} = \alpha + \beta_I(UA3MO)_t + \beta_M R_{Mt} + \varepsilon$$

where:
$R_{bt}$ = return for bank *b* in month *t*
$\alpha$ = pooled intercept term
$\beta_I$ = BHC stock sensitivity to unanticipated changes in the 3-month T-Bill yield
$\beta_M$ = BHC stock sensitivity to changes in the Equal Weighted Market Return
**UA3MO** = unanticipated changes in the 3-month T-Bill yield

The first two-factor model, presented in Table 3, indicates that the Equal Weighted Market Return coefficients ($\beta_M$) are positive and statistically significant at 1% for all three prediction sub-periods and for the overall prediction period spanning from 1995 to 2006, as expected.

The coefficients associated with unanticipated changes in the 3-Month T-Bill ($\beta_1$) are negative and statistically significant at the 1% level for the first two prediction sub-periods and for the overall prediction period, consistent with existing related literature. The third prediction sub-period, 2003 through 2006, yields a positive coefficient that is statistically insignificant.

The third prediction sub-period is unique in that it is characterized by a consistent increase in short-term rates driven by Federal Reserve actions. For most of the sub-period, it could be argued that the Fed is relatively transparent in its desire to steadily increase the Fed Funds rate in the near term. Enhanced market anticipation of rate changes, as a result, is a possible source of inconsistency in short-term rate sensitivity estimated during this sub-period.

**Table 4 – Two-Factor Model: Unanticipated Changes in the 10-Year T-Note**

| | $\alpha$ | $\beta_2$ | $\beta_M$ | $R^2$ | n |
|---|---|---|---|---|---|
| 1995 - 1998 | 0.014 | -4.114 | 0.685 | 0.197 | 12,762 |
| | (20.39)*** | (-14.45)*** | (54.39)*** | | |
| 1999 - 2002 | 0.008 | -0.150 | 0.109 | 0.007 | 13,449 |
| | (9.72)*** | (-0.44) | (9.66)*** | | |
| 2003 - 2006 | 0.001 | 0.961 | 0.563 | 0.152 | 13,318 |
| | (1.38) | (4.43)*** | (48.92)*** | | |
| 1995 - 2006 | 0.010 | -2.291 | 0.341 | 0.061 | 39,531 |
| | (24.65)*** | (-13.62)*** | (50.20)*** | | |

**For all BHC's ('b'):**

$$\mathbf{R}_{bt} = \alpha + \beta_1(\mathbf{UA10YR})_t + \beta_M \mathbf{R}_{Mt} + \varepsilon$$

where:
$\mathbf{R}_{bt}$ = return for bank *b* in month *t*
$\alpha$ = pooled intercept term
$\beta_1$ = BHC stock sensitivity to unanticipated changes in the 10-year T-Note yield
$\beta_M$ = BHC stock sensitivity to changes in the Equal Weighted Market Return
**UA10YR** = unanticipated changes in the 10-year T-Note yield

The second two-factor model, presented in Table 4, again indicates that the Equal Weighted Market Return coefficients ($\beta_M$) are positive and statistically significant at 1% for all three prediction sub-periods and for the overall prediction period.

The coefficients associated with unanticipated changes in the 10-Year T-Note ($\beta_2$) are negative and statistically significant at 1% for Sub-Period 1 and for the overall prediction period. A negative coefficient is also estimated for Sub-Period 2, but is statistically insignificant. Sub-

Period 3's positive and significant coefficient is contrary to the hypothesized relationship. This result suggests that, on average during the sub-period, BHC's are found to be more asset-sensitive to interest rate changes relative to liabilities. In other words, rate increases (decreases) create more (less) revenue from interest rate sensitive assets compared to prior sub-periods.

**Stage 3(a)**

In addition to the pooled estimates presented above, both of the two-factor models from Stage 2 are also estimated for each BHC to obtain each BHC's sensitivity to unanticipated changes in both yield series. The coefficients are estimated by BHC over each 48-month sub-period. The resulting estimated coefficients, or sensitivities, are subsequently utilized as dependent variables in Stage 3 cross-sectional analysis. The explanatory variables include various on- and off-balance sheet positions held by the various BHC's obtained from Y-9C reports. Y-9C information is reported quarterly, but is averaged over the corresponding sub-period.[2]

The first bank-specific explanatory variable is the notional value of interest rate derivatives, not held for trading, standardized by asset size (PCTNOT). As indicated in Stage 2, BHC stock returns are, on average, negatively impacted by increases in interest rates. Consequently, the hypothesis is that those banks utilizing a higher measure of interest rate derivatives are taking these positions to reduce interest rate risk. Based on this assumption, the anticipated sign of the coefficient is positive – in other words, increasing PCTNOT is anticipated to result in a less-negative interest rate sensitivity. Conversely, a negative sign associated with the coefficient is consistent with interest rate speculation activity. Again the hypothesized sign is based on the conclusion that BHC's, on average, are negatively impacted by unanticipated interest rate changes. If only those BHC's with positive interest rate sensitivities are considered, on the other hand, the hypothesized signs for hedging and speculating activity would reverse.

PCTNOT is unique in that its anticipated sign depends on the sign of the "initial" interest rate sensitivity coefficients being analyzed and on the type of activity being represented by derivative usage (i.e. hedging vs. speculating). Ultimately, the hypothesis is based on the assumption of negative interest rate sensitivities (on average) and on the assumption of derivatives being used for hedging. Therefore, a positive sign is expected.

The second explanatory variable is the more-traditional gap measure. Gap is calculated as all assets that are expected to reprice or mature within one year minus all liabilities that are expected

[2] I utilize an algorithm to match Y-9C data with corresponding CUSIP numbers based on bank name and total assets.

to reprice or mature within one year, also standardized by total assets (PCTGAP). A positive gap suggests that an increase in short-term rates would be beneficial to a bank's net interest margin which makes the anticipated sign for PCTGAP positive. An increase in PCTGAP results in more interest rate sensitive assets relative to interest rate sensitive liabilities, which in turn affects interest rate sensitivity positively. If PCTGAP is positive, an increase in interest rates is beneficial to net interest margin, all else equal. In contrast to PCTNOT, the initial sign associated with the interest rate sensitivity coefficient does not change the hypothesized positive sign of PCTGAP. A relatively higher gap measure will result in a higher NIM when rates rise, all else equal. If interest rate sensitivity is negative initially, higher PCTGAP results in a less-negative interest rate sensitivity.

The third hypothesized bank-specific characteristic is the level of 1-4 family residential loans held "in-house" (PCTRES). Hirtle (1997) utilizes a similar measure (found to be statistically significant) along with a number of other bank-specific measures in order to model variation in BHC interest rate sensitivities. Residential loans held by banks typically have interest rates that are fixed for longer periods of time than many other interest-earning assets (i.e. higher durations). The hypothesized sign of this coefficient is negative. A bank with higher levels of PCTRES is expected to experience a larger drop in market equity given the relatively high duration of mortgage assets.

Table 5 provides summary statistics of each explanatory variable by sub-period for the BHC's sampled.

**Table 5 – Summary Statistics of the Stage 3 Independent Variables by Sub-Period**

| Sub-Period | PCTNOT | PCTGAP | PCTRES |
|---|---|---|---|
| **1995 - 1998** | | | |
| MEAN | 12.52% | 13.63% | 16.67% |
| *STD DEV* | *98.63%* | *16.60%* | *10.51%* |
| **1999 - 2002** | | | |
| MEAN | 15.15% | 6.03% | 15.14% |
| *STD DEV* | *153.65%* | *22.76%* | *10.28%* |
| **2003 - 2006** | | | |
| MEAN | 18.19% | 11.62% | 12.97% |
| *STD DEV* | *200.79%* | *27.73%* | *8.52%* |

PCTNOT = Notional Amount of IR Derivatives / Total Assets
PCTGAP = GAP / Total Assets
PCTRES = Loans on 1-4 Family Residences / Total Assets

The results of the regression model with the sensitivities of BHC returns to unanticipated changes in the 3-month T-Bill rate series as the dependent variable are given in Table 6. The estimated impacts of each of the bank-specific independent variables are shown with the corresponding t-statistic listed below. This model is run for each 48-month sub-period and for the overall sample period.

**Table 6 – Bank Specific Characteristics in Relation to Interest Rate Sensitivity**
Sensitivity of Stock Returns to Changes in the **3-Month T-Bill** yield as the Dependent Variable

| Sub-Period | $\alpha$ | $\theta_N$ | $\theta_G$ | $\theta_R$ | $R^2$ | N |
|---|---|---|---|---|---|---|
| **1995-1998** | -2.956<br>(-1.87)** | 0.697<br>(1.81)** | -0.404<br>(-0.08) | 1.582<br>(0.23) | 0.027 | 122 |
| **1999-2002** | -1.894<br>(-1.76)* | 0.106<br>(0.61) | 14.209<br>(3.77)*** | -15.504<br>(-2.53)*** | 0.154 | 128 |
| **2003-2006** | 4.176<br>(3.43)*** | -0.305<br>(-0.76) | -0.375<br>(-0.10) | -17.399<br>(-2.41)*** | 0.069 | 130 |
| **1995-2006** | -0.056<br>(-0.07) | -0.036<br>(-0.30) | 6.059<br>(2.53)*** | -12.728<br>(-3.21)*** | 0.046 | 380 |

$\beta_{Ib} = \alpha + \theta_N(PCTNOT_b) + \theta_G(PCTGAP_b) + \theta_R(PCTRES_b) + \varepsilon$
where:

$\beta_I$ = Bank b sensitivity to changes in the 3-month T-Bill yield
$\alpha$ = Intercept term
$\theta_N$ = BHC stock sensitivity to changes in PCTNOT
$PCTNOT_b$ = Notional Amt of IR Derivatives / Total Assets
$\theta_G$ = BHC stock sensitivity to changes in PCTGAP
$PCTGAP_b$ = GAP / Total Assets
$\theta_R$ = BHC stock sensitivity to changes in PCTRES
$PCTRES_b$ = Residential Loans / Total Assets

For the first sub-period (1995 to 1998), only PCTNOT is found to have a statistically significant impact (at the 5% level) on short-term interest rate sensitivity. The estimated coefficient for PCTNOT is positive, consistent with the story that BHC's use interest rate derivatives to hedge interest rate risk.

In the second sub-period (1999 to 2002), both PCTGAP and PCTRES are found to have a statistically significant impact on short-term interest rate sensitivity at the 1% level. The PCTGAP coefficient is positive, as expected. Higher levels of interest rate sensitive assets relative to interest rate sensitive liabilities result in less-negative interest rate sensitivities. On the other hand, the PCTRES estimate is negative. This is also consistent with expectations since higher levels of residential loans are found to result in more-negative levels of interest rate sensitivity.

PCTRES is again found to have a negative and statistically significant impact (at the 1% level) over the third sub-period (2003 to 2006) on short-term interest rate sensitivity, while the other two coefficients are not statistically significant.

For the overall sample period spanning from 1995 to 2006, PCTNOT is statistically insignificant. The other two factors, PCTGAP and PCTRES, are statistically significant at the 1% level with their expected positive and negative signs, respectively.

The positive and significant PCTNOT coefficient in the first sub-period indicates that the variation in the relative level of interest rate derivative usage has some power in explaining variation in short-term interest rate sensitivities among BHC's. The lack of statistical significance for PCTNOT in the second and third sub-periods indicates that this explanatory power is subsequently lost.

The results of the regression model with the sensitivities of BHC returns to unanticipated changes in the 10-year T-Note rate as the dependent variable are given in Table 7.

**Table 7 – Bank Specific Characteristics in Relation to Interest Rate Sensitivity**
Sensitivity of Stock Returns to Changes in the **10-Year T-Note** yield as the Dependent Variable

| Sub-Period | $\alpha$ | $\theta_N$ | $\theta_G$ | $\theta_R$ | $R^2$ | N |
|---|---|---|---|---|---|---|
| **1995-1998** | -2.596 | 0.606 | 7.190 | -2.401 | 0.064 | 122 |
| | (-2.22)** | (2.14)** | (1.99)** | (-0.48) | | |
| **1999-2002** | -2.709 | 0.400 | 14.782 | -2.223 | 0.144 | 128 |
| | (-2.38)** | (2.17)** | (3.72)*** | (-0.34) | | |
| **2003-2006** | 2.142 | -0.114 | 2.673 | -10.111 | 0.053 | 130 |
| | (2.64)*** | (-1.16) | (1.12) | (-2.08)** | | |
| **1995-2006** | -0.620 | 0.163 | 4.323 | -9.095 | 0.043 | 380 |
| | (-0.96) | (1.67)* | (2.10)** | (-2.70)*** | | |

$\beta_{2b} = \alpha + \theta_N(PCTNOT_b) + \theta_G(PCTGAP_b) + \theta_R(PCTRES_b) + \varepsilon$
where:

$\beta_2$ = Bank b sensitivity to changes in the 10-year T-Note yield
$\alpha$ = Intercept term
$\theta_N$ = BHC stock sensitivity to changes in PCTNOT
$PCTNOT_b$ = Notional Amt of IR Derivatives / Total Assets
$\theta_G$ = BHC stock sensitivity to changes in PCTGAP
$PCTGAP_b$ = GAP / Total Assets
$\theta_R$ = BHC stock sensitivity to changes in PCTRES
$PCTRES_b$ = Residential Loans / Total Assets

For the first and second sub-periods, PCTNOT and PCTGAP are both positive and statistically significant at the 5% level or better, consistent with the hypothesized relationships, implying that higher levels of these variables result in less-negative interest rate sensitivity.

For the full sample period, PCTNOT is positive at the 10% level and PCTGAP is positive at the 5% level, again consistent with the hypothesized signs. These results are similar to those utilizing the 3-month T-Bill as the dependent variable.

Although the sign of PCTRES was negative in all of the sub-periods and over the full sample period, it was statistically significant only in the third sub-period and the overall sample period (5% and 1%, respectively). The negative sign associated with the coefficient is consistent with the hypothesis that higher levels of residential loans held "in-house" result in higher rate sensitivity from higher market-implied discount rates on these assets.

**Stage 3(b)**

Stage 3(b) utilizes the same BHC-sub-period observations as in Stage 3a. The primary difference in this stage is that these observations are split into two groups for both the 3-month and 10-year sensitivities. The observations utilizing the BHC sensitivities to unanticipated changes in the 3-month T-Bill are split into those with negative interest rate sensitivities and positive interest rate sensitivities. The same is done for BHC sensitivities to unanticipated changes in the 10-year T-Note, producing four splits: positive 3-month, negative 3-month, positive 10-year and negative 10-year sensitivities.

The hypothesized impacts of both PCTGAP and PCTRES are unchanged with a change in the assumption of the initial sign of the sensitivity. Regardless of the sign of the initial sensitivity to either the T-Bill or T-Note series, a higher PCTGAP will – all else equal – result in more interest rate-sensitive assets relative to interest-rate sensitive liabilities. Consequently, a bank with a higher relative gap measure will tend to benefit to a greater degree in a rising interest rate environment, resulting in a positive hypothesized value for PCTGAP. The expected effect of higher PCTGAP is either a less-negative interest rate sensitivity or a more-positive interest rate sensitivity.

Similarly, all else equal, higher levels of residential loans held "in-house" translates into higher levels of higher-duration assets. Regardless of the initial sensitivity, a higher level of PCTRES will typically result in a higher duration measure of bank assets. The stock price of a BHC with higher relative levels of residential loans will tend to fall more in a rising interest rate environment. The expected effect of higher PCTRES is either a more-negative interest rate sensitivity or a less-positive interest rate sensitivity – thus, the hypothesized sign for PCTRES is negative.

The primary motivation for the positive/negative split in this stage is the possibility of additional information on interest rate derivative usage (PCTNOT) and its impact on interest rate sensitivity. Unlike PCTGAP and PCTRES, the expected impact of PCTNOT depends on two assumptions: 1) whether the BHC is utilizing these derivatives to hedge interest rate risk and 2) the initial sign of the interest rate sensitivity of the BHC.

If assuming that the usage of these derivatives (PCTNOT) is primarily hedging-related (consistent with the hypothesis in Stage 3(a)), then the hypothesized sign of this variable depends on the sign of the initial interest rate sensitivity. Again, assuming PCTNOT reflects interest rate derivatives used as hedging tools, higher levels of PCTNOT are hypothesized to result in lower magnitudes of interest rate sensitivities. If a BHC has a negative initial interest rate sensitivity, (under the hedging assumptions), PCTNOT is anticipated to have a positive sign. On the other hand, if a BHC has a positive initial interest rate sensitivity, PCTNOT is anticipated to have a negative sign.

Table 8 is similar to Table 6, with both analyzing the impact of the three bank-specific characteristics on the sensitivity to unanticipated changes in the T-Bill – Table 8, however, splits the BHC's into those with positive and negative sensitivities by sub-period and for the overall sample period.

**Table 8 – Bank Specific Characteristics**
**NEGATIVE 3-Month T-Bill Sensitivities / POSITIVE 3-Month T-Bill Sensitivities**

| BHC's with POSITIVE 3-Month T-Bill Sensitivities | | | | | | |
|---|---|---|---|---|---|---|
| Sub-Period | $\alpha$ | $\theta_N$ | $\theta_G$ | $\theta_R$ | $R^2$ | N |
| 1995-1998 | 5.075 | 1.632 | -2.024 | 0.853 | 0.259 | 34 |
| | (2.47)** | (3.05)*** | (-0.30) | (0.08) | | |
| 1999-2002 | 5.079 | -0.132 | 2.768 | -9.742 | 0.107 | 42 |
| | (4.07)*** | (-1.20) | (0.67) | (-1.53) | | |
| 2003-2006 | 7.913 | -1.103 | -1.185 | -18.732 | 0.1147 | 81 |
| | (7.05)*** | (-2.04)** | (-0.36) | (-2.60)*** | | |
| 1995-2006 | 6.505 | -0.080 | 0.397 | -10.77 | 0.040 | 157 |
| | (8.16)*** | (-0.61) | (0.16) | (-2.46)** | | |
| **BHC's with NEGATIVE 3-Month T-Bill Sensitivities** | | | | | | |
| Sub-Period | $\alpha$ | $\theta_N$ | $\theta_G$ | $\theta_R$ | $R^2$ | N |
| 1995-1998 | -6.207 | 0.158 | 1.725 | 1.119 | 0.005 | 87 |
| | (-4.55)*** | (0.50) | (0.42) | (0.20) | | |
| 1999-2002 | -5.514 | 0.258 | 6.166 | -5.092 | 0.043 | 87 |
| | (-5.40)*** | (0.62) | (1.65)* | (-0.83) | | |
| 2003-2006 | -5.789 | -0.060 | 6.051 | 5.906 | 0.077 | 50 |
| | (-4.51)*** | (-0.61) | (1.62) | (0.85) | | |
| 1995-2006 | -5.981 | 0.006 | 4.934 | -0.016 | 0.024 | 224 |
| | (-8.83)*** | (0.06) | (2.31)** | (-0.00) | | |

PCTGAP indicates no significance in explaining varying *positive* sensitivities, as shown in Table 8. However, PCTGAP is found to be significantly positive in explaining varying *negative* sensitivities for the overall sample period, which is consistent with the hypothesized sign.

PCTRES, on the other hand, indicates no significance in explaining varying *negative* sensitivities, however, it is found to be significantly negative in explaining the varying *positive* sensitivities – also consistent with the hypothesized sign.

Overall, PCTNOT produces inconsistent results as no significance is indicated relating to *negative* sensitivities. Sub-Period 1 and Sub-Period 3 are found to have some significance relating to *positive* sensitivities. However, the signs of these coefficients switch from positive to negative.

Table 9 is similar to Table 7, with both analyzing the impact of the three bank-specific characteristics on the sensitivity to unanticipated changes in the T-Note. Table 9 splits BHC's into those with positive and negative sensitivities by sub-period and for the overall sample period.

**Table 9 – Bank Specific Characteristics**
**NEGATIVE 10-Year T-Note Sensitivities / POSITIVE 10-Year T-Note Sensitivities**

| BHC's with POSITIVE 10-Year T-Note Sensitivities | | | | | | |
|---|---|---|---|---|---|---|
| **Sub-Period** | **α** | **$\theta_N$** | **$\theta_G$** | **$\theta_R$** | **$R^2$** | **N** |
| **1995-1998** | 7.284 | -0.235 | 0.791 | -20.678 | 0.166 | 24 |
| | (3.52)*** | (-0.54) | (0.09) | (-1.93)* | | |
| **1999-2002** | 3.729 | 0.087 | 11.064 | -7.872 | 0.326 | 56 |
| | (4.66)*** | (1.03) | (4.26)*** | (-1.48)* | | |
| **2003-2006** | 4.475 | -0.179 | 3.053 | -10.891 | 0.088 | 81 |
| | (5.58)*** | (-0.93) | (1.30) | (-2.12)** | | |
| **1995-2006** | 4.548 | 0.039 | 4.700 | -10.512 | 0.113 | 161 |
| | (7.95)*** | (0.46) | (2.60)*** | (-3.28)*** | | |
| **BHC's with NEGATIVE 10-Year T-Note Sensitivities** | | | | | | |
| **Sub-Period** | **α** | **$\theta_N$** | **$\theta_G$** | **$\theta_R$** | **$R^2$** | **N** |
| **1995-1998** | -6.195 | 0.287 | -0.721 | 2.880 | 0.019 | 97 |
| | (-6.57)*** | (1.10) | (-0.26) | (0.74) | | |
| **1999-2002** | -6.147 | 9.605 | 3.626 | 1.645 | 0.020 | 73 |
| | (-4.93)** | (0.72) | (0.75) | (0.22) | | |
| **2003-2006** | -2.803 | -0.007 | 1.944 | -0.139 | 0.020 | 50 |
| | (2.64)*** | (-0.12) | (0.96) | (-0.04) | | |
| **1995-2006** | -5.340 | 0.087 | 2.141 | 0.406 | 0.009 | 220 |
| | (-8.61)*** | (0.86) | (1.09) | (0.13) | | |

From Table 9, PCTGAP is significantly positive for Sub-Period 2 and the overall sample period, as hypothesized, in relating to varying *positive* sensitivities. PCTGAP is also found to be positive in relation to *negative* sensitivities, but none of these coefficients are found to be statistically significant.

PCTRES is significantly negative for all periods in relation to *positive* sensitivities, consistent with the hypothesized sign – no significance is found for PCTRES in relation to *negative* sensitivities. PCTNOT indicates no significance in explaining sensitivities to unanticipated changes in the 10-year T-Note.

Overall, PCTGAP and PCTRES maintain their hypothesized relationships to interest rate sensitivity after the positive/negative splits, although statistical significance falls. PCTNOT is found to have no significance following the split while the intercept terms increase in magnitude and significance.

## 5. Conclusions / Summary

The testing performed in Stage 1 of the empirical analysis indicates that the three Treasury yield series considered are cointegrated, consistent with much of the existing literature. This result allows for modeling predicted rates utilizing VAR analysis, which is considered to be superior to first-differencing or detrending due to the loss of information that can result with these two methods.

After the predicted rate series for both the 3-month and 10-year Treasuries are formed, I compute the corresponding series of unanticipated interest rate changes. I then regress BHC stock returns on equal-weighted market returns and each of the two series of unanticipated rate changes. Stage 2 results are also generally consistent with existing literature which finds that BHC stock returns are negatively impacted by interest rate increases.

Following the estimation of each BHC's sensitivities to the unanticipated changes in the 3-month and 10-year rate series, three BHC-specific factors are tested for their impact on these sensitivities. The usage of non-traded interest rate derivatives, represented by PCTNOT, generally does not have a statistically significant impact on determining the sensitivities to unanticipated changes in the 3-month T-Bill with the exception of the first sub-period. PCTNOT is, however, found to impact the sensitivities to unanticipated changes in the 10-year T-Note to a greater degree.

The two on-balance sheet measures, relative levels of gap and residential loans are both statistically significant at the 1% level in determining the BHC's sensitivities to unanticipated changes in the 3-month rate series throughout the overall sample period. PCTGAP and PCTRES were also found to be statistically significant in determining sensitivities to unanticipated changes in the 10-year rate series.

Overall, the results may indicate a trend in the impact of interest rate derivative usage as the impact seems to decline (statistically) throughout the overall sample period. Conversely, it appears that the significance of the two on-balance sheet measures (PCTGAP and PCTRES) holds up better over time.

## References


Bae, S., 1990. Interest Rate Changes and Common Stock Returns of Financial Institutions: Revisited, *The Journal of Financial Research* 13, 71-79.

Bradley, M., and S. Lumpkin, 1992. The Treasury Yield Curve as a Cointegrated System, *Journal of Financial and Quantitative Analysis* 27, 449-463.

Brenner, R., R. Harjes, and K. Kroner, 1996. Another Look at Models of the Short-Term Interest Rate, *Journal of Financial and Quantitative Analysis* 31, 85-107.

Brewer III, E., W. Jackson, and J. Moser, 1996. Alligators in the Swamp: The Impact of Derivatives on the Financial Performance of Depository Institutions, *Journal of Money, Credit and Banking* 28, 482-497.

Carter, D., and J. Sinkey, Jr., 1998. The Use of Interest Rate Derivatives by End-Users: The Case of Large Community Banks, *Journal of Financial Services Research* 14, 17-34.

Dinenis, E., and S. Staikouras, 1998. Interest Rate Changes and Common Stock Returns of Financial Institutions: Evidence from the UK, *The European Journal of Finance* 4, 113-127.

Engle, R., and C. Granger, 1987. Co-Integration and Error Correction: Representation, Estimation, and Testing, *Econometrica* 55, 251-276.

Flannery, M., and C. James, 1984. The Effect of Interest Rate Changes on the Common Stock Returns of Financial Institutions, *The Journal of Finance* 39, 1141-1153.

Fraser, D., J. Madura, and R. Weigand, 2002. Sources of Bank Interest Rate Risk, *The Financial Review* 37, 351-368.

Ghazanfari, F., H. Rogers, and P. Sarmas, 2007. The Effect of the Federal Reserve Interest Rate Policies on the Returns of Commercial Banks Stocks, *Journal of Financial Services Marketing* 11, 349-359.

Hirtle, B., 1997. Derivatives, Portfolio Composition, and Bank Holding Company Interest Rate Exposure, *Journal of Financial Services Research* 12, 243-266.

Madura, J., and E. Zarruk, 1995. Bank Exposure to Interest Rate Risk: A Global Perspective, *The Journal of Financial Research* 18, 1-13.

Sierra, G., and T. Yeager, 2004. What Does the Federal Reserve's Economic Value Model Tell Us About Interest Rate Risk at U.S. Community Banks?, *Federal Reserve Bank of St. Louis Review* 86, 45-60.

Simons, K., 1995. Interest Rate Derivatives and Asset-Liability Management by Commercial Banks, *New England Economic Review* January, 17-28.

Staikoursas, S., 2006. Financial Intermediaries and Interest Rate Risk: II, *Financial Markets, Institutions & Instruments* 15, 225-272.

Yangru, W., and H. Zhang, 1997. Do Interest Rates Follow Unit-Root Processes? Evidence from Cross-Maturity Treasury Bill Yields, *Review of Quantitative Finance and Accounting* 8, 69-81.